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EVALUATION OF CRITICAL SUCCESS FACTORS FOR SIX SIGMA IMPLEMENTATION IN INDIAN MANUFACTURING SMES

DHARMENDRA TYAGI, V. K. SONI & V. K. KHARE

Department of mechanical Engineering, Maulana Azad National Institute of Technology, Bhopal, Madhya Pradesh, India

ABSTRACT

This research paper is to evaluate and present the results from the online survey conducted in various Indian manufacturing small and medium enterprises (SMEs), mainly to focus critical success factors (CSFs) for implementing Six Sigma in Indian manufacturing small and medium enterprises and identified most crucial critical success factors for Six Sigma implementation in SMEs of manufacturing sector in India. The paper is based on survey questionnaire apposite for Indian manufacturing SMEs and the result investigation of the present study is based on factor analysis and descriptive statistics. The results are investigated by the factor analysis and reveal the impact of different CSFs on the Indian manufacturing SMEs.

KEYWORDS: Six Sigma, CSFs, Indian Manufacturing SMEs & Factor Analysis

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Original Article

INTRODUCTION

Six-Sigma is one of the most important tools of quality in large sized organizations. However, its application in SMEs (Small and Medium Sized Enterprises) is still at the early stage of development (Antony, et al., 2005; Kaushik, et al. 2012; Antony, 2008b; Kumar, M., & Antony, J., 2008). The minimum number of Small and Medium Sized Enterprises to adopt Six Sigma worldwide, is somewhat discouraging. The present work is an attempt to explore the facts about Indian manufacturing SMEs and also highlight the most critical success factors (CSFs), for implementing Six Sigma in Indian SMEs of manufacturing sector.

Small and medium sized enterprises (SMEs) comprise the mass of businesses around the world and, therefore, play a key role in the growth of the national economy of any country (Soti, et al., 2012; Antony, et al., 2005; Kureshi, et al., 2010; Kim, et al., 2008). For example, Small and medium sized enterprises are the major contributors to employment and economic output (Husband, S., & Mandal, P., 1999; Antony, et al., 2005).

According to the act approved by the Government of India in October 2006, MSMEs (Micro, Small and Medium Enterprises) are classified as follows (Deshmukh, S.V., & Chavan, A., 2012; Singh, et al., 2015; Raghuvanshi, et al., 2017).

Table 1: Classification of Enterprises into Different Categories

Enterprises	Investment In Plant And Machinery	
	Manufacturing	Service
Micro	Up to Rs 25 lakhs	Up to Rs 10 lakhs
Small	Between 25 lakhs to Rs 5 crores	Between 10 lakhs to Rs2crores
Medium	Between Rs 5 crores to 10 crores	Between Rs 2crores to 5crores

Six Sigma was originated by the Motorola as a technique for attaining business excellence in 1986(Narasimhan, 2009). History of Six Sigma, explored by the researchers (Folaron, 2003; Harry, M.J., & Schroeder, R., 2000; Montes, F.J.L., & Molina, L.M., 2006; Pisani, et al., 2009; Arumugam, et al., 2016) and related it to the year of the 1920s efforts of many quality specialists, statisticians and mathematicians. Subsequently, Harry and Bill Smith analyzed and combined the methods for analysis, defined goal and refined goal, with the statistical tools for analysis.

All Organizations look for ways to improve their production and management processes in order to remain competitive in the market (Nabeel,et al. 2012). Six-Sigma is an improvement philosophy in QM to make enterprises more competitive with the aim of achieving further business excellence (Nedeliakova, et al., 2017; Huq, 2006) and the role of Six Sigma philosophy in business excellence is the business processes measurement that are incorporated into the business system (Kanji, 2008). Since, the origin of Six Sigma, increasing competitiveness of organization seems to be extremely common in the sectors of business (Aboelmaged, 2011). Six-Sigma became a strategic methodology for diminishing variation in process by focusing on breakthrough and continuous improvements (Andersson, et al., 2006; Pugna, et al., 2016). However, Huq (2006) also explains that, the skills development to use all Six Sigma tools effectively; is necessary to reach the high aim of 3.4 DPMO (Defects per Million Opportunities).

Ravichandran, (2006) highlighted that, if an enterprise achieves the level of Sigma above 5, then it is labeled a 'world-class' enterprise. If the level of Sigma is between 3 and 5, then the enterprises performance is supposed to be of 'industrial average' and if level of Sigma is less than 3 then such an enterprise is classified into a category of 'non-competitive' in the market. This is shown in table 2.

Table 2: Classification of an Enterprise using Levels of Sigma

Level of Sigma	Defects per Million	Category
1	700000	Non-competitive
2	310000	
3	67000	Industrial average
4	6200	
5	230	World-class
6	3.4	

Critical Success Factors for Implementing Six Sigma

The adoption and implementation of QM approaches by small medium enterprises such as Six Sigma are slow (Kumar, M., & Antony, J., 2008). For growing adoption and implementation of such approaches need to identify critical success factors. Antony (2008a) highlighted that small and medium enterprises can implement Six Sigma methodology more successfully than large enterprises, if top management is fully committed and involved.

CSFs are those factors that are significant to the success of any organizations, it means that if objectives depended on the key factors are targeted; the organizations must fail (Antony, J., & Banuelas, R., 2002), several other definitions of critical success factors by researchers in published literature (Boynton, A., & Zmud, R., 1984; Antony, J., & Banuelas, R., 2002; Brotherton, B., & Shaw, J., 1996). The published literature highlights numerous critical success factors, such as communication, cultural change, fact-based decision making and leadership, as most critical for implementing Six Sigma in organizations (Moosa, K., &Sajid, A., 2010; Coronado, R.B., &Antony, J., & Banuelas, R., 2002; Nonthaleerak, P., & Hendry, L., 2008; Antony, et al., 2005; Kumar, 2007; Mahanti, R., & Antony, J., 2009; Alsmadi, et al., 2012; Kumar, et al., 2009; Chakrabarty, A., & Tan, K.C., 2009; Desai, et al., 2012) The most critical five CSFs highlighted by Kumar (2007)

were linking Six Sigma to customers, management involvement and commitment, cultural change, vision & plan and education, training and quality culture (Davison, L., & Shaghana, K.A., 2007). Hilton, et al. (2008) highlighted critical success factors, for successfully implementing Six Sigma in Australian hospital.

Cheng (2007), investigated Six Sigma activities in Taiwan at domestic industries. An appropriate research formation included performance and managerial variables, for the industrial surroundings in Taiwan. Managerial variables (independent) included the factors of customer, strategy, training and project whereas the performance variables (dependent) include the factors of cost, delivery, quality and flexibility and Cheng (2013) examined the relationship between business strategy and Six Sigma in Taiwan.

The three CSFs, Linkage between Six Sigma and customer, management commitment, involvement and participation and Linkage between Six Sigma and business strategy of an enterprise were found crucial CSFs for implementing Six Sigma effectively within UK manufacturing small medium enterprises (Antony, et al., 2005). Brun (2011) identified critical success factors, for implementing Six Sigma in Italian Companies and also published literature presented, that identified key factors help SMEs for implementing Six Sigma and for assessment of these key factors were completed by questionnaire prepared (Kumar, et al., 2009; Antony, et al., 2005; Kumar, 2007; Jeyaraman, K., &Leam, K.T., 2010 and Desai, et al., 2012), distributed it to targeted SMEs for assessment of gaps in CSFs. Data collected for analysis by either semi structured interview or online survey conducted. After analysis of the data collected by above methods, researchers have been identified suitable key factors (CSFs) for implementation of Six Sigma in SMEs (Antony, et al., 2005). Summary of indentified critical success factors from published literature (Desai, et al., 2012; Wu, C., & Lin, C., 2009; Padhy, R.K., &Sahu, S., 2011; Singhal, et al., 2011; Ahirwar, M., & Verma, D., 2014; Erturk, et al., 2016) are shown in table 3.

Table 3: Summary of Identified Critical Success Factors

Authors	Critical Success Factors
Kwak,et al. (2006); Hahn, et al. (1999);Coronado, R.B., &Antony, J., & Banuelas, R. (2002); Goh (2002)	Top management commitment
Hendersen,et al. (2000)	Link to human resources (e.g. promotions, bonuses, etc.), organizational infrastructure, and top management support.
Coronado, R.B., & Antony, J.(2002);Antony, J., & Banuelas, R.. (2002)	Training, understanding of Six Sigma methodology, cultural change, management commitment and involvement, project management skills, understanding of tools and techniques, project selection, linking Six Sigma to customers, organizational infrastructure, linking Six Sigma to suppliers, linking Six Sigma to business strategy
Starbid (2002)	Identify customer needs, core processes and measures
Hayes (2002)	Executive engagement, Management involvement, resources and communications
Johnson,et al. (2003)	Continuing education and training of participants, Sustained and visible management commitment, project leadership and clear expectations
Anbari,et al. (2004)	Cultural change, management commitment, implementation methodology, project planning and selection, continuous training, organizational involvement and project management and control
Kundi (2005)	Role of innovative techniques, cultural change, use of Six Sigma methodology, top management support, organizational infrastructure, employee training and education of Six sigma and effective communication of Six Sigma program

Table 3: Contd.,

Burton, et al. (2005)	Cultural change, leadership commitment and support, communication, make proper investment in resources, linking to business plan and focus on customers and results
Martins, et al. (2006)	Knowledge of process of teamwork, continuous support of Six Sigma champion, project management skill of project leader and cross functional teamwork
Chakrabarty, A., & Tan, K.C. (2007)	Customer focus, top management commitment, clear performance metrics, cultural change and education and training
Kumar, M., & Antony, J. (2008)	Top management involvement and linking to strategy
Mahanti, R., & Antony, J.(2009)	Training and education and management commitment and involvement
Antony, et al. (2009), Kumar, et al. (2009)	Cultural change and organizational infrastructure
Desai, et al. (2012)	Leadership for Six Sigma, Project prioritization and selection, Project management skills, Understanding of Six Sigma methodology, Linking Six Sigma to suppliers, Linking Six Sigma to employees, Linking Six Sigma to business strategy, Linking Six Sigma to customers, Training, Cultural change, Organizational infrastructure, Management involvement and participation
Ahirwar, M., & Verma, D. (2014)	Management commitment and involvement, Understanding of Six Sigma methodology, tools, and techniques, Linking Six Sigma to business strategy, Linking Six Sigma to customers, Project selection, reviews and tracking, Organizational infrastructure, Cultural change, Project management skills, Liking Six Sigma to supplier and Training.
Erturk, et al. (2016)	Information Technology Infrastructure, Communication, Associating Six Sigma with suppliers, Associating Six Sigma with Human Resources, Associating the Six Sigma with customers, The operating Strategy associate with Six Sigma, The Tools and Techniques Understandings in the Six Sigma Methodology, Project Prioritization and Selection, Project Management Skills, Education, Organizational Infrastructure, The Participation of the Management and Commitment and Cultural Exchange
Daniela, et al. (2016)	Clear roles in the Six Sigma structure, Full time dedicated Black Belts, Clearly allocated Green Belts, IT or Knowledge management structure, Strategic project selection, Long term plus short term benefit project selection, Projects selected for important stakeholders, Periodic and constant project review, Behavioral characteristics of Black Belts and Green Belts, Training for Master Black Belts and Black Belts, Massive training in Yellow Belts or White Belts, Master Black Belts support provided, Adherence of project management with DMAIC steps, Use of Six Sigma tools and Use of project management tools

Methodologies used for Implementing Six Sigma

Researchers all over the globe suggest two key strategy for implementing Six Sigma: DMAIC and DFSS, DMAIC stands for Define, Measure, Analyze, Improve and Control (Erick, et al., 2010, Sahoo, et al., 2008; Chang, et al., 2012; Mast, J.D., & Lokkerbol, J., 2012) and DFSS stands, for Design for Six Sigma, the major intention of both methods are special or different. Initially Six Sigma were effectively implemented by these methods and later on a few modifications were exist such as DMADV and DCOV, DMADV stands for Define, Measure, Analyze, Design and Verify and DCOV stands for Design, Characterize, Optimize and Verify (Arumugam, et al., 2016; Chakrabarty, A., & Tan, K.C.,

2007;Nedeliakova, et al., 2017).

OBJECTIVE OF RESEARCH AND METHODOLOGY

The key objective of present research work is to "analyze the critical success factors for implementing Six Sigma within Indian SMEs of manufacturing sector" and this objective can be achieved by setting following research questions systematically-

- To what extent are the Indian manufacturing SMEs implementing Six Sigma?
- What are the most Critical Success Factors for implementing Six Sigma in Indian SMEs of manufacturing sector?

The present study has progressed by setting research objectives that lead to an in-depth review of literature. To achieve these objectives, a research methodology was prepared as shown in figure 1.

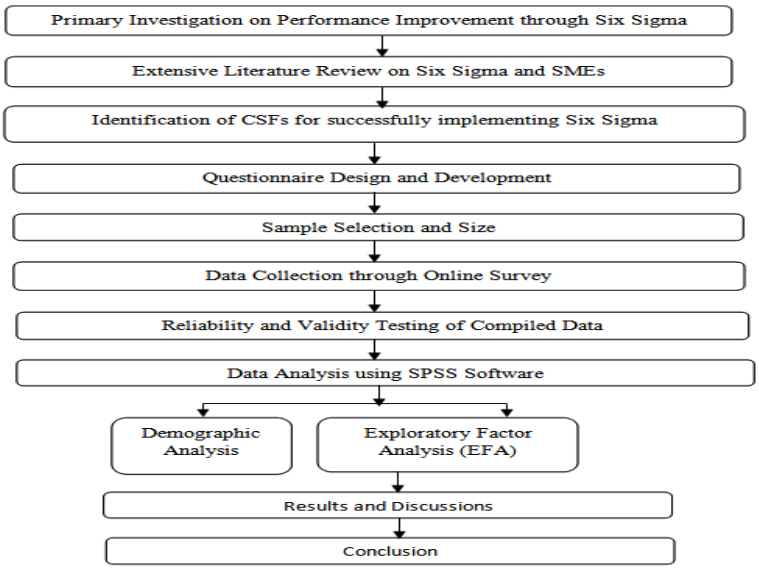

Figure 1: Research Methodology

An online questionnaire survey of Indian SMEs of manufacturing sector was conducted to understand the status of implementation of Six Sigma and also present study can help to explore the CSFs for implementing Six Sigma. The questionnaire was mailed to 1500industrial respondents and requested them to read the survey questions and respond as soon as possible. Useful responses were received from301enterprises within two and half months by taking three follow-ups and response rate was 20.06%.The questionnaire focused on Critical Success Factors for implementing Six Sigma as well as it included basic information of enterprise. Critical Success Factors are measured by seven point likert type scale (1 = Not at all important, 7 = Crucial).

RESULTS AND DISCUSSIONS

Demographic Information of SMEs

Data were collected through questionnaire survey from three hundred one organizations. Out of three hundred one organizations, one hundred twenty four organizations were found to be small sized enterprises, while one hundred seventy seven organizations satisfied the criteria of medium sized enterprises as shown in Figure 2.

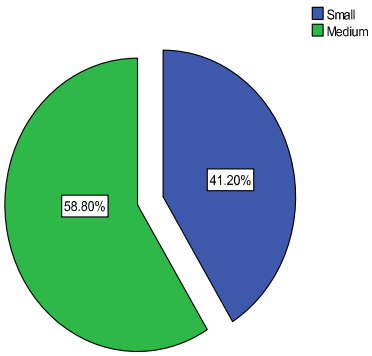

Figure 2: Size Distribution of Indian Manufacturing SMEs

Critical Success Factor Analysis

To meet the objective of Critical Success Factors for implementing Six Sigma in Indian manufacturing SMEs as whole the industrial respondents were asked to rank the CSFs in a scale of 1 to 7 as discussed above. Accordingly, industrial respondents have put up their rating of all CSFs and then analyzed critical success factors by running EFA (Exploratory Factor Analysis).

Enterprises were asked to identify the most crucial factors that were felt to be CSFs to implement Six Sigma programming Indian SMEs of manufacturing sector. The result analysis revealed that most of the industrial respondents declared that Leadership, Linking Six Sigma to suppliers, Customers satisfaction, Fact based decision making and Linking Six Sigma to business strategy(see table 7) are found most crucial CSFs, for implementing Six Sigma in Indian manufacturing SMEs.

Reliability test is performed to check internal consistency of survey data (Lande, M.S., & Shrivastava, R.L., 2016). Cronbach's alpha is a measure of reliability and coefficient of reliability should be greater than 0.70 is acceptable.

Table 4: Reliability Statistics

Cronbach's Alpha	N Of Items
.958	27

The KMO and Bartlett's Test of Sphericity tests the adequacy of the correlation matrix (Robert, H., 2006) and yielded a value of 7667.006and an associated level of significance smaller than 0.001. Thus, the hypothesis that the correlation matrix is an identity matrix can be rejected. Factor analysis output gives you a thought about the communalities (see table 6) before and after extraction. Principle component analysis (PCA) works on the initial assumption that all variance is common; therefore all communalities in table are 1 before extraction. The communalities in the Extraction column show the common variance in the data structure.

Table 5: KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.940
Bartlett's Test Of Sphericity	Approx. Chi-Square	7667.006
	df	351
	Sig.	.000

Table 6: Communalities

Factor Code	Critical Success Factors	Initial	Extraction
CSF1	Management commitment, involvement and participation	1.000	.845
CSF2	Project prioritization and selection	1.000	.785
CSF3	Project management skills	1.000	.828
CSF4	Leadership	1.000	.831
CSF5	Linking Six Sigma to business strategy	1.000	.826
CSF6	Fact based decision making	1.000	.783
CSF7	Strategic vision	1.000	.684
CSF8	Organizational infrastructure	1.000	.851
CSF9	Specialized team for Six Sigma	1.000	.889
CSF10	Communication	1.000	.705
CSF11	Cultural change	1.000	.796
CSF12	Employees' commitment	1.000	.758
CSF13	Linking Six Sigma to employees	1.000	.830
CSF14	Integrating Six Sigma with the financial infrastructure	1.000	.544
CSF15	Process documentation	1.000	.828
CSF16	Make proper investment in resources	1.000	.834
CSF17	Regular audits	1.000	.732
CSF18	Uses of innovative techniques	1.000	.700
CSF19	Understanding of six sigma methodology	1.000	.728
CSF20	Knowledge Sharing	1.000	.680
CSF21	Understanding of six sigma tools and techniques	1.000	.728
CSF22	Education and training	1.000	.703
CSF23	Suppliers involvement	1.000	.821
CSF24	Linking Six Sigma to customers	1.000	.853
CSF25	Linking Six Sigma to suppliers	1.000	.871
CSF26	Customers satisfaction	1.000	.874
CSF27	Customers involvement	1.000	.846
	Extraction method: Principal component analysis.		

Graphically, the plot has shown a steep slope between the large factors and the gradual trailing off of the rest of the factors (see figure 3). The point at which the curve first begins to straighten out is considered to indicate the maximum number of factors to extract (Robert, 2006).

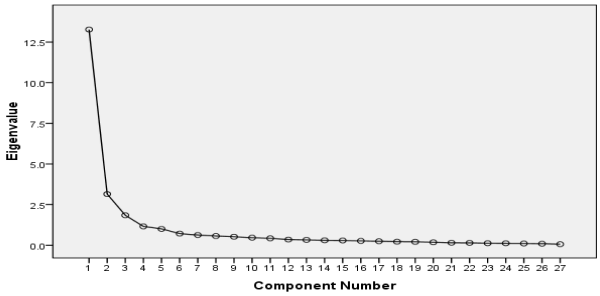

Figure 3: Scree Plot

Factor Analysis to reduce the data size and form the families of similar dimensions based on the Correlation Coefficient and their factor loadings. Analysis revealed that six factors extracted and Cronbach's alpha for each factor is shown in table 5, along with factor loadings. Value of Cronbach's alpha for each factor were found more than 0.75.

Table 7: Technical Factors Extracted

S. No.	Factor Code	Critical Success Factors	Factor Loadings	Proposed Factor Label
1	CSF6	Fact based decision making	.944	Management involvement and Leadership ***(ALPHA=0.944)***
	CSF5	Linking Six Sigma to business strategy	.919	
	CSF4	Leadership	.901	
	CSF1	Management commitment, involvement and participation	.838	
	CSF3	Project management skills	.829	
	CSF2	Project prioritization and selection	.822	
	CSF7	Strategic vision	.784	
2	CSF25	Linking Six Sigma to suppliers	.977	Customers and Suppliers involvement ***(ALPHA=0.953)***
	CSF26	Customers satisfaction	.933	
	CSF24	Linking Six Sigma to customers	.884	
	CSF23	Suppliers involvement	.857	
	CSF27	Customers involvement	.854	
3	CSF20	Knowledge Sharing	.860	Understanding of Six Sigma Philosophy ***(ALPHA=0.886)***
	CSF18	Uses of innovative techniques	.790	
	CSF19	Understanding of six sigma methodology	.775	
	CSF21	Understanding of six sigma tools and techniques	.747	
	CSF22	Education and training	.742	
4	CSF15	Process documentation	.840	Resources utilization and audits ***(ALPHA=0.877)***
	CSF16	Make proper investment in resources	.803	
	CSF17	Regular audits	.710	
	CSF14	Integrating Six Sigma with the financial infrastructure	.651	
5	CSF9	Specialized team for Six Sigma	.925	Functional teams and effective communication ***(ALPHA=0.907)***
	CSF8	Organizational infrastructure	.897	
	CSF11	Cultural change	.826	
	CSF10	Communication	.675	
6	CSF13	Linking Six Sigma to employees	.851	Employees involvement ***(ALPHA=0.790)***
	CSF12	Employees' commitment	.633	

CONCLUSIONS

For global competitiveness, Indian SMEs of manufacturing sector are motivated to achieve overall organizational performance in their business era. Importance of Six Sigma initiative is growing in Indian manufacturing SMEs to satisfy the need of organizations. The present study was aimed to identify the most important CSFs, for implementing Six Sigma in Indian SMEs of manufacturing sector. Analysis revealed that, five CSFs (Leadership, Linking Six Sigma to suppliers, Customers satisfaction, Fact based decision making and Linking Six Sigma to business strategy) out of 27 were found most important.

It can also be concluded that the exploratory factor analysis (EFA) has identified six factors from the list of 27critical success factors. These factors are represented (see table 7) by the specific statements written to replicate the proposed factors label. Reliability test for each proposed factor in an exploratory factor analysis were computed Cronbach's alpha value and this value of alpha were found above 0.75, which indicates high overall internal consistency among the

factors representing proposed factors label.

SMEs of manufacturing sector in India have already implemented Six Sigma initiative as a breakthrough continuous improvement (CI) strategy for satisfying to the key performance of small and medium enterprises. An extensive study regarding critical success factors for implementing Six Sigma in Indian manufacturing SMEs was necessary since Six Sigma initiative is receiving more importance among Indian manufacturing SMEs. The present study can help Indian SMEs of manufacturing sector who have yet not implemented Six Sigma methodology.

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